

Simulation and comparison of various MPPT techniques

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Abstract - The photovoltaic (PV) system is one of the renewable energies that attract the attention of researchers in the recent decades. The active solar energy harvesting techniques by using the Photovoltaic cells, which converts the solar energy directly into the Electric Energy. The energy harvesting from the Sun is required so that maximum utilization can be taken. It is important to operate PV energy conversion systems in the maximum power point (MPP) to maximize the output energy of PV arrays. The maximum power produced varies with both irradiance and temperature. Since the conversion efficiency of PV arrays is very low, it requires maximum power point tracking (MPPT) control techniques. The MPPT is the automatic control algorithm to adjust the power interfaces and achieve the greatest possible power harvest during moment to moment variations of light level, shading, temperature, and photovoltaic module characteristics. The model which extracts the maximum power of photovoltaic module and increases the efficiency of the overall system in terms of power generated by the photovoltaic module is compared with previously proposed models. All the techniques and concept required and used to design the model are explained and the results are shown in comparative form. A model of PV module and DC/DC boost converter with the different techniques of MPPTs was simulated using MATLAB/Simulink environment.

Key words: Boost converter, MPPT, Simulink, PV module.

1. INTRODUCTION

The most common attention of alternative energies is solar energy. There are two types of technology employed in solar energy namely solar thermal and solar cell. A PV module offers several advantages such as requirement of little maintenance and no environmental pollution.

Renewable sources of energy are a hot topic acquiring a growing importance in the world due to its consumption and exhaustion of fossil fuel. The photovoltaic (PV) power system is becoming

increasingly important as the most available renewable source of energy since it is clean with little maintenance and without any noise. Nevertheless, PV systems have problems, such as the conversion with low radiation (in general less than 17%), as well as the nonlinear characteristic that depends on irradiation and temperature in its operation which change the amount of electric power generated.

The location of the maximum power point can be determined using different algorithms. Maximum Power Point Tracking (MPPT) techniques are used to maintain the PV array's operating point at its maximum power point (MPP) and extract the maximum power available in PV arrays. Due to the various MPPT methods, different research in PV systems has presented a comparative analysis of MPPT techniques. Indeed, some papers present comparative study among only few methods and others present a comparison of several MPPT methods, based on simulations, under the energy production point of view. The MPPT techniques are evaluated considering different irradiation and temperature variation and calculation of the energy supplied by the complete PV array.

2. Components Required

DC-DC Boost converter, switch, MOSFET, Capacitor, Inductor, Simulink Software.

3. MPPT Techniques

There are different techniques used to track the maximum power point. Few of the most popular techniques are:

1. Perturb and observe
2. Incremental conductance
3. Grey wolf optimization

4. Perturb and observe

Perturb & Observe (P&O) is the simplest method. In this we use only one sensor, that is the voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement. The time complexity of this algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing on both the directions. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm. However the method does not take account of the rapid change of irradiation level (due to which MPPT changes) and considers it as a change in MPP due to perturbation and ends up calculating the wrong MPP. To avoid this problem we can use incremental conductance method.

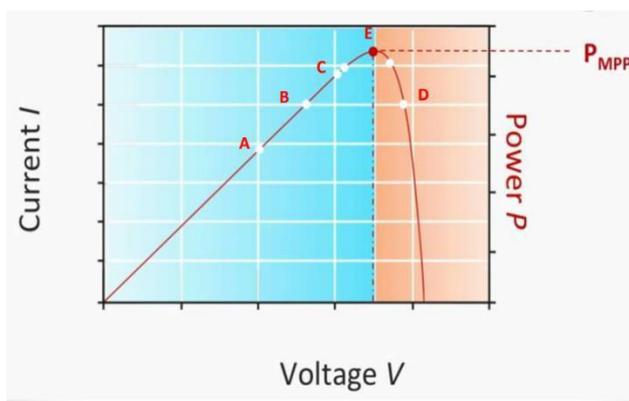


Fig -1: V-I and V-P curves of p&o

5. Incremental conductance

Incremental conductance uses two voltage and current sensors to sense the output voltage and current of the PV array. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dI/dV and $-I/V$. This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P and O.

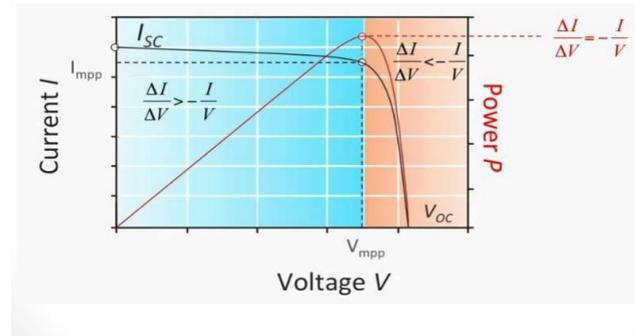


Fig -2: V-I and V-P curves of IC.

6. Grey Wolf Optimization

Grey wolf optimization (GWO) is a population based meta-heuristics algorithm simulates the leadership hierarchy and hunting mechanism of grey wolves in nature proposed by Mirjalili et al. in 2014. Grey wolves are considered as apex predators, which they are at the top of the food chain. Grey wolves prefer to live in groups (packs), each group contains 5-12 members on average.

The first level is called Alpha (α). The alpha wolves are the leaders of the pack and they are a male and a female. They are responsible for making decisions about hunting, time to walk, sleeping place and so on. The pack members have to dictate the alpha decisions and they acknowledge the alpha by holding their tails down. The alpha wolf is considered the dominant wolf in the pack and all his/her orders should be followed by the pack members.

The second level is called Beta (β). The betas are subordinate wolves, which help the alpha in decision making. The beta wolf can be either male or female and it considers the best candidate to be the alpha when the alpha passes away or becomes very old. The beta reinforces the alpha's commands throughout the pack and gives the feedback to alpha.

The third level is called Delta (δ). The delta wolves are not alpha or beta wolves and they are called subordinates. Delta wolves have to submit to the alpha and beta but they dominate the omega (the lowest level in wolves' social hierarchy).

The fourth (lowest) level is called Omega (ω). The omega wolves are considered the scapegoat in the pack; they have to submit to all the other dominant wolves. They may seem are not important individuals in the pack and they are the last allowed wolves to eat. The whole packs are fighting in case of losing the omega.

The hunting operation is usually guided by the alpha. The beta and delta might participate in hunting occasionally. In the mathematical model of hunting behavior of grey wolves, we assumed the alpha, beta and delta have better knowledge about the potential location of prey.

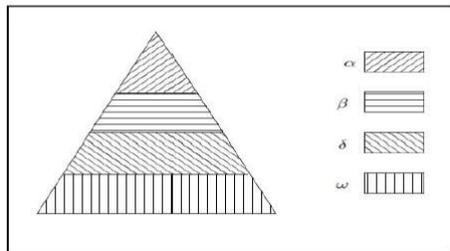


Fig -3: Social Hierarchy.

7. Conclusion

The use of solar energy is essential for providing solutions to the environmental problems and also energy demand. The vast development to improve the efficiency by the MPPT algorithms encouraged the domestic generation of power using solar panels. The available MPPT techniques based on the number of control variables involved, types of control strategies, circuitry, and applications are possibly useful for selecting an MPPT technique for a particular application for grid tied or standalone mode of operations. This review has included many recent hybrid MPPT techniques along with their benefits for mismatched conditions such as partial shading, Non uniformity of PV panel temperatures, and dust effects.

It is observed that Perturbation and Observation and Incremental Conductance methods are simple and used by many researches, but they have the slow tracking and low utilization efficiency. To overcome the drawbacks, grey wolf optimization techniques are used in the present days by which the efficiency is increased.

PV systems are suitable for residential and/or industrial applications as it provides a regulated AC output voltage that may also track the input mains utility voltage in phase and amplitude at hundreds to thousands of watts. Thus MPPT system can be deployed to get maximum amount of power to take advantage of solar energy.

8. Future scope

The work that had been carried out by the researchers, the designing of MPPT controller, should

be extended by tracking larger number of input parameters which are varying with respect to the time such as parameters variations of the system. In order to get accurate MPPT point, the recent mathematical algorithms such as Z-infinity algorithms should be implemented. The work that has been carried out to the DC-DC converter is limited only by considering high switching frequency.

But the output voltage THD values are not improved much so that the research should be carried out in this area; a filter circuit's configuration should be improved. For the inverter circuits, the grid tied inverters are having the problem that if the grid fails, the customer will not get any supply even though there is power generation from the PV system. This should be considered as a serious problem and the research should be carried out in this area.

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